BARNYARD MANURE

PRODUCTION, COMPOSITION, CONSERVATION, REINFORCEMENT AND VALUE

OHIO

Agricultural Experiment Station

WOOSTER, OHIO, U. S. A., JUNE, 1912.

BULLETIN 246

The Bulletins of this Station are sent free to all residents of the State who request them. When a change of address is desired, both the old and the new address should be given. All correspondence should be addressed to EXPERIMENT STATION, Wooster, Ohio

OHIO AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

J. D. GUTHERY, *President*.....Marion
HENRY L. GOLL, *Secretary*.....Swanton
D. L. SAMPSON, *Treasurer*.....Cincinnati
FRANK B. BLOOD.....Conneaut
GEORGE E. SCOTT.....Mt. Pleasant

STATION STAFF

CHARLES E. THORNE, M. S. A., *Director*

DEPARTMENTAL ORGANIZATION

ADMINISTRATION

THE DIRECTOR, *Chief*
WILLIAM H. KRAMER, *Bursar*
D. W. GALEHOUSE, *Assistant*
DORA ELLIS, *Mailing Clerk*
GLENN HALL, *Engineer*
W. K. GREENBANK, *Librarian*

AGRONOMY

C. G. WILLIAMS, *Chief. Associate in soil fertility investigations*
F. A. WELTON, B. S., *Assistant*
WILLIAM HOLMES, *Farm Manager*
C. A. PATTON, *Assistant*
E. C. MORR, *Office Assistant*
C. H. LEBOLD, *Asst. Foreman*

ANIMAL HUSBANDRY

B. E. CARMICHAEL, M. S., *Chief*
J. W. HAMMOND, M. S., *Assistant*
GEO. R. EASTWOOD, B. S., *Assistant*
DON C. MOTE, M. S., *Assistant*
W. J. BUSS, *Assistant*
ANTHONY RUSS, *Herdsman*
E. C. SCHWAN, *Shepherd* (Carpenter

BOTANY

A. D. SELBY, B. S., *Chief*
TRUE HOUSER, B. S., *Assistant* (Germantown)
F. K. MATHIS, *Office Assistant*
E. L. NIXON, B. S., *Assistant*
D. C. BABCOCK, A. B., *Assistant*
J. H. MUNCIE, A. B., *Assistant*

CHEMISTRY

J. W. AMES, M. S., *Chief*
E. W. GAITHER, B. S., *Assistant*
GEO. E. BOLTZ, B. S., *Assistant*
J. A. STENIUS, B. S., *Assistant*
GEORGE MCCLURE, *Assistant*

CLIMATOLOGY

J. WARREN SMITH, *Chief*
C. A. PATTON, *Observer*

COOPERATION[1]

THE DIRECTOR, *Chief*
M. O. BUGBY, B. S., *Assistant*
W. M. COOK, A. B., *Assistant*
W. L. ELSER, B. S., *Assistant*
C. W. MONTGOMERY, *Assistant*
F. N. MEEKER, B. S., *Assistant*
G. B. MAYNADIER, *Assistant*
A. L. HIGGINS, B. S. *Assistant*
H. W. HAWTHORNE, *Assistant*
H. P. MILLER, B. S., *County Agent*
F. L. ALLEN, *County Agent*
ELIZABETH GREENSLADE, *Office Assistant*

DAIRYING

C. C. HAYDEN, M. S., *Chief*
A. E. PERKINS, M. S , *Assistant*
T. R. MIDDAUGH, *Office Assistant*
R. D. GEORGE, *Herdsman*
W. N. MCMILLAN, *Herdsman* (Lancaster)[2]
M. C. MEEKER, *Herdsman* (Mansfield)[3]

ENTOMOLOGY

H. A. GOSSARD, M. S., *Chief*
J. S. HOUSER, M. S. A., *Associate*
W. H. GOODWIN, B. S., *Assistant*
R. D. WHITMARSH, M. S., *Assistant*
J. L. KING, *Assistant*

FORESTRY

EDMUND SECREST, B. S., *Chief*
J. J. CRUMLEY, Ph. D., *Assistant*
A. E. TAYLOR, *Assistant*
J. W. CALLAND, B. S., *Assistant*
D. E. SNYDER, *Office Assistant*

HORTICULTURE

W. J. GREEN, *Vice Director, Chief*
F. H. BALLOU, *Assistant*
E. J. RIGGS, B. S., *Assistant*
PAUL THAYER, B. S., *Assistant*
VICTOR HERRON, *Assistant*
C. W. ELLENWOOD, *Office Assistant*
ORA FLACK, *Foreman of Orchards*
W. E. BONTRAGER, *Foreman of Grounds*
C. G. LAPER, *Foreman of Greenhouses*

NUTRITION

E. B. FORBES, Ph. D., *Chief*
A. F. D. WUSSOW, M. S., *Assistant*
M. HELEN KEITH, A. M., *Assistant*
F. M. BEEGLE, B. S., *Assistant*
C. W. KNUDSEN, B. S., *Assistant*
CHARLES M. FRITZ, B. S., *Assistant*

SOILS

THE DIRECTOR, *Chief*

DIVISION OF SOIL TECHNOLOGY

GEORGE N. COFFEY, Ph. D., *Associate*
E. R. ALLEN, M. S., *Assistant*
H. FOLEY TUTTLE, M. S., *Assistant*

DIVISION OF EXPERIMENT FARMS

District Experiment Farms

Northeastern Test-Farm, Strongsville.
EDWARD MOHN, *Resident Manager*

Southwestern Test-Farm, Germantown.
HENRY M. WACHTER, *Resident Manager*

Southeastern Test-Farm, Carpenter.
H. D. LEWIS, *Resident Manager*
LEWIS SCHULTZ, *Horticultural Foreman*

Northwestern Test-Farm, Findlay.
JOHN A. SUTTON, *Resident Manager*

County Experiment Farms

Western District

CHARLES MCINTIRE, *Agent in charge*, Troy
VICTOR HERRON, *Hort. Ass't*, College Hill
P. C. HERRON, *Agron. Ass't*, Mt. Healthy

Miami County Experiment Farm, Troy
JOSEPH BROWN, *Resident Manager*

Paulding County Experiment Farm, Paulding
A. E. SMITH, *Resident Manager*

Clermont County Experiment Farm, Owensville
HOWARD ELLIOTT, *Resident Manager*

Hamilton County Experiment Farm, Mt. Healthy
——— ——— *Resident Manager*

[1]In cooperation with Bureau of Plant Industry, U. S. Department of Agriculture.
[2]In cooperation with Boys' Industrial School. [3]In cooperation with Ohio State Reformatory.

BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 246 JUNE, 1912.

BARNYARD MANURE

PRODUCTION, COMPOSITION, CONSERVATION, REENFORCEMENT, AND VALUE

J. W. AMES and E. W. GAITHER

The data reported in this bulletin have been obtained through investigations carried on in the stable, field and chemical laboratory, and supplement the information contained in Bulletin 183, published in 1907. In addition to the investigations carried on at this Station, there are included other results, referring to the care and management of manure, which have been compiled from other sources.

The field experiments herein reported have been conducted by the Department of Agronomy of the Station, and those referring to the production of manure, by the Department of Animal Husbandry. The part contributed by the Department of Chemistry has been the analysis of the manures and soil, and the presentation of the accumulated data in the present form.

The valuations assigned to the fertilizer constituents of manure in this bulletin are: phosphorus 8.25 cents, nitrogen 15.84 cents, and potassium 5.3 cents per pound. The valuations assigned the crops are: corn 50 cents per bushel, stover $3 per ton, oats 40 cents per bushel, wheat 90 cents per bushel, straw $2 per ton, and clover and timothy hay $8 per ton.

COMPOSITION OF MANURE

Table I gives the average composition of horse, cattle and sheep manure produced at this Station under various conditions. The detailed results from which this and following tables were compiled are given in Tables XVII to XXI, inclusive, of the addenda.

It will be noted from Table I that the amounts of potassium and nitrogen in manure from animals are largely in excess of the phosphorus contained. Owing to this fact, manure is not a properly balanced fertilizer. The results obtained from experiments with fertilizers low in phosphorus, when used upon soils deficient in this element, show that the full value of nitrogen and potassium cannot be secured unless there is a sufficient supply of phosphorus present. It is therefore necessary to reinforce manure with phosphorus to obtain the best returns from its use. Results obtained by the addition of phosphorus to manure are shown in Table XI, page 742.

TABLE I—Average percentage composition of farm manure including litter.

	Moisture	Ash		Organic matter		Phosphorus		Potassium		Nitrogen	
		Total	Water soluble	Total	Water soluble	Total	Water soluble	Total	Water soluble	Total	Water soluble
Horse manure.....	59.16	5 30	2.120	33.04	1.540	.1080	.0570	.636	.480	.695	.365
Cattle (dairy)....	79 05	2.45	1.597	18 50	1.328	.0965	.0486	.520	.504	.572	.285
Cattle (steers) ...	77.85	3.15	1.430	18.91	1.330	.2080	.0744	459	.424	.726	.404
Sheep.....	63 61	4.97	2 473	30.73	1 988	.2230	.1300	1.010	.976	1 439	.605

The average amount and composition of solid and liquid excrement from mature animals is given in Table II. These data were compiled from different sources and may be considered a fair average.

TABLE II—The daily amount and composition of solid and liquid excrement voided by mature animals.

	Pounds Per animal		Percentage composition					
			Nitrogen		Phosphorus		Potassium	
	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid
Horse.....	35.50	8 000	.495	1.20	.13	Trace	.200	1.24
Cattle.....	52.00	19.400	.324	0.95	.09	.012	.124	0.79
Sheep.....	2.25	1 500	.650	1 68	.20	.013	.190	1.76
Hogs.....	6.00	3.300	.600	0.30	.20	.055	.370	0.83

It will be apparent from this table that the liquid excrement is much richer in nitrogen and potassium than the solid excrement, and that it contains nearly half the amount of these elements voided by the animal. This being true, too much stress cannot be laid upon the importance of caring for the manure in such a way that none of the liquid portion is allowed to go to waste.

PRODUCTION OF MANURE

The amount of manure produced per animal in a given time varies considerably under different conditions, so that it is impossible to state accurately just what amount will be obtained. The more important factors in the production of any kind of stable manure are nature and amount of ration, character and quantity of litter, the economic function of the animal, and the kind of floor upon which the manure accumulates. If the feeding is done according to scientific principles, using a balanced ration, the amounts of phosphorus, nitrogen and potassium, which will be voided by the same animal under similar conditions but fed different rations, will not vary to any considerable extent.

From the results of experiments conducted at this and other stations. there is presented in Table III a fair estimate of the amount of manure ready for field application which should be obtained from the four principal farm animals, excluding that produced while the animals are in the yards or at work.

TABLE III—Daily and annual production of manure, by the four leading farm animals.

	Pounds per day	Tons per year
Cattle O. A. E. S. Average 227 Steers	43	7.80
Sheep O. A. E. S., Average 336 Sheep	4	0.75
Horses	35	6.00
Hogs	9	1.70

The amounts of manure from cattle and sheep as given in this table were produced in experiments conducted by the Department of Animal Husbandry at this Station, under conditions similar to those prevailing on representative farms in Ohio. The pounds of fertilizing constituents contained in manure, including litter, obtained per year per 1000 pounds live weight of animal are included in Table IV.

TABLE IV—Pounds of manure, including litter, obtained per year per 1000 pounds live weight by farm animals, and the pounds of ash, organic matter and plant food contained in the manure.

		Horse Lbs.	Steer Lbs.	Sheep Lbs.
Manure per 1,000 pounds live weight		13 080	15,700	12,100
Constituents contained:				
Moisture		7,738.1	12,222 5	7,696.8
Ash	Total	693.2	494 8	601.4
	Water soluble	277.3	224.5	299.2
Organic matter	Total	4,321.6	2,968.9	3,718.3
	Water soluble	201.4	208 8	240 5
Phosphorus	Total	14.13	32.66	26.98
	Water soluble	7.46	11.68	15.73
Potassium	Total	83.19	72 06	122 21
	Water soluble	62.78	66.58	115 10
Nitrogen	Total	90.9	113.10	174.1
	Water soluble	47.74	63.43	75.21
Average weight of animal		1,100	1,302	84.

EARTH VERSUS CEMENT FLOORS FOR STABLES

To determine the relative value of manure produced, a series of feeding tests were conducted upon earth and cement floors and it was found that more manure was produced upon the cement floors and a greater percentage of the phosphorus, potassium and nitrogen contained in the feed consumed was recovered in the manure. The analyses of manure recovered from animals stabled upon cement floors show an increased value of $4.48 per year for every 1,000 pounds live weight, over that recovered from animals standing on earth floors. See Table V.

TABLE V—Comparison of steer manure recovered from earth and cement floors.

	Pounds recovered per 1,000 pounds live weight		Percent of plant food in feed recovered in manure				Value per year	Number of steers fed
	Per day	Per year	Nitrogen	Phosphorus	Potassium	Value per ton		
Cement floors	47 5	17,326	75	78	88	$2.96	$25 66	28
Earth floors	41 3	15 052	62	78	78	2.81	21 18	30
Difference in favor of cement floors	6 2	2 274	13	00	10	$0.15	$ 4.48	.

The cost of concreting stalls, where the work has been done by the ordinary labor of the farm, has been about 9 cents per square foot, or $4.50 per steer, allowing 50 square feet for each steer. It is evident that, when cattle are fed for six months on cement floors, the increased value of the manure alone for two such feeding periods is sufficient to cover the cost of floors.

The amounts of fertilizing elements, in the rations fed to animals, which are voided in the solid and liquid excrement have been determined at different experiment stations. The results are as follows: Mississippi, experimenting with young fattening steers, reports 84 percent of the nitrogen, 92 percent of the potassium and 86 percent of the phosphorus voided.[1] Pennsylvania, experimenting with milch cows, reports 83 percent of the nitrogen, 92 percent of the potassium and 75 percent of the phosphorus voided.[2]

A comparison of the above figures with the results in Table V, which shows that 75 percent of the nitrogen, 88 percent of the potassium and 78 percent of the phosphorus contained in the feed has been recovered, indicates clearly that by the use of cement stalls, practically all of these elements excreted by the animal can be recovered.

[1] Farmers' Bulletin, U. S. D. A., 192, P. 13
[2] Farmers' Bulletin, U. S. D A., 192.

In the sheep feeding experiments made by this Station on earth floors, 64 to 72 percent of the nitrogen, 86 to 97 percent of the potassium and 79 to 95 percent of the phosphorus contained in the feed has been recovered in the manure.

If cement feeding pens had been used it is reasonable to expect that a much larger amount would have been recovered.

FERMENTATION OF MANURE

Fermentation is the process by which manure is decomposed or rotted. It begins as soon as the manure is voided by the animal, and may be considered a continuation of the process of disintegration of plant substances begun in the digestive tract of the animal. If conditions are favorable, this process will continue until eventually all the organic matter in the manure is broken up into various gases and nothing is left but the mineral or ash constituents. This disintegration is caused by the action of bacteria upon the various organic bodies in the manure.

The bacteria are divided into two classes; aerobic bacteria, which require oxygen from the air for their development, and anaerobic bacteria, which do not develop in the presence of air, but thrive best when air is excluded.

The conditions which influence the relative activity of these two kinds of bacteria, divide manure into two classes, commonly called "hot" and "cold" manure. Horse and sheep manure belong to the first class, cattle and hog manure to the second. Owing to the relatively dry and loose condition of horse and sheep manures, they permit a free circulation of air and ferment readily with the generation of much heat. Hog and cattle manures contain much more moisture and are more compact than horse and sheep manures, and therefore are not subject to such a rapid fermentation as are the manures of the first class.

AEROBIC FERMENTATION

Aerobic bacteria thrive best in manure when it is loose and only a moderate amount of water is present. By their power of oxidation they generate a large amount of heat and, if the process is not interrupted, the temperature of the manure will be raised to the point where fire fanging and in some cases spontaneous combustion takes place.

This form of fermentation is undesirable in the manure pile, for it destroys the humus-forming organic matter and liberates nitrogen in a free state, which cannot be recovered.

Aerobic fermentation can be retarded by compacting the manure; by the addition of water or other substances which will exclude air, and by covering the manure to prevent the escape of the carbon dioxide gas formed by the decomposition of organic matter.

The losses which occur from this fermentation are much less in the case of cattle and hog manures than from horse and sheep manures, which favor the growth of aerobic bacteria.

ANAEROBIC FERMENTATION

Anaerobic bacterial action or fermentation takes place under conditions which are the reverse of those which favor the development of aerobic bacteria. By compacting the manure and thereby excluding air, the organic matter is slowly decomposed without any marked generation of heat. The manure is thus changed into the most desirable form for soil application without the loss of nitrogen. Marsh gas and carbon dioxide are the principal products of anaerobic fermentation.

CARE OF MANURE

The importance of properly storing manure is evident from the facts above mentioned, concerning the conditions which affect the growth of different bacteria and the nature of the manures produced by different animals. Attention is directed to the methods of storing which will prevent aerobic and encourage anaerobic fermentation.

When manure is piled in the open, provision should be made for the recovery of the seepage water and its return to the manure. This requirement is partially met by a method used in France which is essentially as follows: The manure is placed on a rectangular floor raised slightly at the sides and of sufficient area to hold the manure produced when piled five to seven feet high. It should be provided with a basin across the center and the floor inclined so that the leachings will drain into the basin, from which they can be pumped over the pile when needed. The pile should be made so that there will be as little of the surface exposed as possible, keeping the top flat and sides as vertical as possible. When one pile is as large as desired, make another on the other side of the basin. While the first lot of manure is fermenting it should be kept moist, by pumping the seepage water over the top whenever needed. By following this method the fermentation can be fairly well controlled and the loss due to leaching will be reduced to a minimum.

Another method of caring for manure in the open is to build a concrete pit of sufficient capacity and throw the manure into it as made, together with all other waste materials, of manurial value, which accumulate upon the farm, rejecting diseased plant residues,

and depending upon the rainfall to keep it moist. If the rainfall is insufficient the manure may be sprinkled occasionally to keep it in proper condition. In sections where the rainfall is very great it may be necessary to provide a cover which will shed the rain in order to prevent the accumulation of too much water in the pit. This method of storing manure has the following advantages: (1) In cold weather the pile does not freeze; (2) the only exposed surface is the top of the heap, thus reducing the aerobic fermentation to a minimum; (3) fermentation goes on evenly throughout the whole mass; (4) the amount of labor required to care for it is somewhat lessened; and (5) the loss of nitrogen will be minimized. The increased labor of handling the manure when it is to be hauled out to the field is more than compensated for by the advantages secured by caring for the manure in this manner.

THE COVERED MANURE SHED

The most popular method of caring for manure in this State is the covered manure shed. To obtain the best results the shed should be provided with a cement floor inclined at each end to allow a spreader to be run in at one end and out at the other; the sides should be sufficiently high to contain all the manure to be stored. The manure should be placed evenly over the floor, and that from horses, cattle, sheep and hogs mixed to prevent, as far as possible, aerobic fermentation and consequent loss of nitrogen. The cattle in the yard should be allowed to trample over it and it may be worked over by the hogs without much danger of loss. In addition to being a storehouse for manure, the shed furnishes a shelter for farm animals which will compact the manure so that the aeorbic fermentation responsible for the loss of nitrogen will be largely prevented.

THE BOX STALL

The production of manure in the box stall is probably the best of the old methods, since it requires the least expenditure of labor. However, more bedding is required to keep the animal clean and the accumulated manure furnishes an ideal breeding place for flies. The manure so produced, if kept evenly distributed over the floor, will be thoroughly compacted and will sustain only a small loss of nitrogen so long as the animal remains upon it, but if the manure is allowed to remain in the stall after the animal is removed there will be considerable loss of nitrogen both as ammonia and as free nitrogen, due to the drying out and breaking up of the uric acid into ammonium carbonate, and to the action of the bacteria on the organic nitrogen compounds.

THE COMPOST HEAP

For use on very light, sandy soil in certain sections, where good results cannot be obtained by the use of fresh manure on account of its tendency to "burn out" the crop, and for soils used for trucking where well rotted manure is to be preferred, it is sometimes necessary to ferment large quantities in the field. Following out the scheme of fermentation outlined in previous pages, the same problem presents itself here, and it becomes necessary to observe the same precautions.

The factors to be considered are: Prevention of loss of nitrogen by fermentation, and of nitrogen, phosphorus and potassium by leaching; and the thorough fermentation of the manure. To meet these requirements the compost should be started by throwing up 4 to 6 inches of soil, with a shallow trench around the base to prevent the accumulation of water. It will be well to cover the soil with a layer of absorbing material such as leaf mould, peat or straw, of sufficient thickness to absorb any liquid which may seep through the manure. The manure should be lightly packed on the layer of absorbing material and if other fertilizing materials, such as phosphates, garbage* or dead leaves, are to be used they may either be mixed with the manure or spread on in alternate layers. The heap is best built conical-shaped and when of sufficient bulk should be covered with from 2 to 4 inches of soil well packed to exclude air. Fermentation will begin immediately and continue until the whole mass is thoroughly rotted. It is advisable to give the pile occasional attention, as it will decrease in bulk, and in settling cracks in the earth covering may be formed which will admit air and cause a loss of the nitrogen content.

The advantages of fermenting manure under proper conditions are: The improvement of its mechanical condition by disintegration of the coarser particles; reduction of bulk; rendering the humus forming substances available in a shorter time, which is especially desirable when the manure is to be used on light soils; the probable rendering of the nitrogen contained in the litter and solid portion of the manure more soluble; furnishing a medium by which waste organic materials may be reduced to a better condition for soil application.

OPEN-YARD MANURE

Manure allowed to accumulate in the open barnyard for a period of from three to six months is from one-half to one-third as valuable as that hauled directly from the stall to the field or properly stored in a manure shed. The fact that the floor of the yard may be hard and that the manure is compacted by animals trampling it, does not

*Care should be exercised not to throw diseased vegetable matter in manure heaps, such as scabby potato parings, etc., as by this means the disease may be carried back to the soil.

prevent loss. The water which falls on the yard must escape either by seepage or surface drainage, and will carry with it the more soluble fertilizing constituents of the manure. Aside from this there will be an additional loss of nitrogen due to the heating of the manure in dry weather.

No farmer can afford to follow the practice of throwing the manure from the stable into the open yard, exposed to the weather and the water from the eaves of the barn roof, when the extra expense of hauling it directly to the field or of storing it properly in a manure shed will be more than compensated for by the increased value of the manure.

APPLICATION OF MANURE

There are three systems of handling and applying manure in general practice: (1) Direct application of fresh manure from stall to field and plowing under, or using as a top dressing; (2) allowing it to accumulate in stalls or manure shed, then applying to the soil immediately before breaking the ground, or as a top dressing; and (3), composting or fermenting the manure before applying.

The system best suited to any particular locality depends upon the texture and topography of the soil, labor and seasonal conditions, and nature of the crop grown. In most localities a combination of two of these systems may be practiced to good advantage.

When practicable the direct application of manure to the soil as soon as possible after it is made is preferable to the other methods, to which attention has been directed. The practice involves less expense and eliminates the loss of nitrogen caused by fermentation when the manure is not properly stored.

PRECAUTIONS

In some sections where the soil is very light or sandy, coarse manure plowed under late in the spring in large quantities may produce harmful results, especially in dry seasons, by making the soil so loose and porous that it cannot retain sufficient moisture.

In truck farming, or market gardening, where the maximum return is desired in the shortest possible time, and where it is not desirable to use coarse manure for obvious reasons, rotted manure should be used.

The loss sustained when manure is hauled directly from the stable to the field will be slight where the land is comparatively level and capable of absorbing most of the rain which falls during the time the manure lies exposed. When the surface drainage takes place too rapidly there is some chance of loss, but owing to the fact that about half the nitrogen and practically all the potassium compounds

in the manure are readily soluble in water, and that the soil has the power of absorbing and fixing these compounds, it is probable that the soluble constituents leached out will be absorbed by the soil after the first one or two inches of rainfall. Subsequently there will be slight danger of loss for the reason that the coarser and more insoluble portions of the manure disintegrate slowly and become soluble only after being incorporated with the soil.

The greatest loss occurring from this method of applying will take place when the manure is spread on snow covering soil frozen after a rain. The water from melting snow will dissolve the soluble material which, instead of coming in contact with the soil, will be shed off by the ice. If the conditions are such that the soil will absorb the water rapidly, there will be little or no loss from manure applied on snow covered soil.

The only objection to using this method alone is that it is not always practicable to get out upon the field with the manure spreader, and this may necessitate using some other method in connection with it. The manure shed will prove very valuable in this case.

RELATIVE VALUE OF FRESH AND ROTTED MANURE

It is possible to ferment manure under such conditions that while it will lose, depending upon the extent of the fermentation, from one-fourth to two-thirds its weight, which is changed into gaseous products, chiefly carbon dioxide and marsh gas, there will be comparatively little loss of nitrogen, phosphorus and potassium, and nearly the same amounts of these elements will be contained in a smaller bulk. Such conditions, however, are seldom if ever attained in ordinary farm practice.

While, therefore, rotted manure is richer in the elements of fertility than fresh manure when equal weights of each are compared, yet considering the fact that from a ton and a half to three tons of fresh manure are required to make a ton of rotted manure, it is apparent that the total quantity of plant food constituents is not increased by the process of fermentation and that any value decomposed manure may have over fresh manure is due to changes in the chemical combinations of the elements contained; to the more favorable bacterial activities in certain soils, or to changes in the mechanical condition of the manure. Except in special cases, where the soil texture is such that it is not desirable to have the manure ferment in the soil, or for certain cropping or gardening conditions, there will be more loss due to waste of time, materials and extra handling involved, than will be gained through the process of fermentation, even under the most perfect conditions.

EFFECT OF MANURE

It is generally supposed that manure exerts beneficial effects upon the soil aside from those due to the plant food and humus forming organic matter it contains. This may be attributed to a combination of the following causes: The stimulating effect it has upon bacterial development; the alkaline nature of the ammonium, potassium, calcium and magnesium carbonates, formed during the process of decomposition, which tend to neutralize soil acidity; improvement in the physical condition of the soil, increasing its water holding capacity; and the solvent action exerted upon certain constituents of the soil by the gases liberated through the decomposition of the organic matter in the manure.

This condition is noticeable in the case of phosphorus, as shown by the analyses of soils taken from the various plots upon which the manure tests at this Station are conducted.

These results which are given in Table VI below, show that the amount of phosphorus soluble in weak acid, from plots receiving no manure is little more than half that from plots receiving yard manure and about one-third that from plots receiving stall manure. Plots 2, 3, 5 and 6, receiving manure reinforced with floats and acid phosphate, show that manure exerts a solvent action upon these materials, when added with them to the soil, in about the same proportion as that exerted upon the phosphates already in the soil. It is not definitely known whether this solvent action is due to the gases and organic acids from the manure or to bacterial action.

TABLE VI—Phosphorus soluble in fifth-normal nitric acid in soils from manure experiment plots.

Plot No.	Treatment	Phosphorus soluble in N-5 HNO_3	
		Percent	Pounds per acre
1	None	.000266	5 32
2	Yard manure and floats	.001122	22.44
3	Stall manure and floats	.002492	49 84
4	None	.000321	6.42
5	Yard manure and acid phosphate	.000408	8.16
6	Stall manure and acid phosphate	.000758	15.16
7	None	.000266	5.32
8	Yard manure and kainit	.000295	5 90
9	Stall manure and kainit	.000509	10.18
10	None	.000278	5.56
11	None	.000241	4.82
12	Yard manure and gypsum	.000363	7.26
13	Stall manure and gypsum	.000416	8.32
14	None	.000336	6.72
15	Yard manure untreated	.000375	7 50
16	Stall manure untreated	.000510	10 20
17	None	.000368	7.36
18	Chemical fertilizer 1	.000413	6.26
19	Chemical fertilizer 2	.000262	5 24
20	None	.000325	6.50
Average unfertilized plots		.000301	6.01
Average yard manure		.000512	10.25
Average stall manure		.000937	18.74

Field experiments conducted at this Station show that much better returns are obtained when manure and a phosphorus carrier are used together than when either is used separately.

The analyses of the stall and yard manure used on these soils, as set forth in Table VII, page 737, show only slightly more phosphorus in the stall manure than in the yard manure, while the analyses of the soils, Table VI, show that approximately twice the amount of phosphorus soluble in weak acid is present in the soil treated with stall manure as compared with that to which yard manure is applied.

Farmers who practice plowing under leguminous crops for green manure will find that the application of from one to three tons of stall manure per acre, just before plowing under the green crop, will increase the effectiveness of the green manure materially. This may be attributed to the bacteria contained in the manure assisting in the decomposition of the green crop.

LOSS DUE TO WEATHERING

The experiment from which the data given in Tables VI and VII have been compiled has been conducted at this Station since 1897, for the purpose of studying the losses of manure due to weathering and the effect of treatment with various reinforcing materials. Fresh manure from stalls in which steers were being fattened was divided into ten 1000-pound portions; two were treated with floats, two with acid phosphate, two with kainit, and two with gypsum, at the rate of 40 pounds per ton, and two were left untreated. One of each of these was spread upon the plots immediately and a duplicate lot of each was allowed to lie exposed to the weather from January to April, in piles 4 x 6 feet and about 10 inches deep, when they were spread upon plots adjoining those previously treated with manure taken directly from the stable. The average chemical analyses of these manures for 5 years are shown in Table VII on page 737.

It is seen from this table that an average of 44.05 percent of the potassium, 32.19 percent of the nitrogen and 14.07 of the phosphorus was lost during these three months—an average loss of 30.10 percent of these three elements. The smallest percentage loss was phosphorus, which is the least soluble, the greatest loss being potassium which is the most soluble, the nitrogen closely following th. potassium.

When the difference in value is considered it is seen that the chemical constituents in a ton of fresh manure would have cost $2.92, and that the ton of such manure produced an increased yield of $3.73, while the comparative chemical value of the leached manure was $1.80 per ton and it returned an increased yield of $2.93, the difference in chemical value being $1.12 per ton and the difference in productive value being $0.80 per ton.

TABLE VII—Composition of treated and untreated steer manure before and after exposure to the weather for three months, from January to April.

Treated with 40 lbs. material per ton		Ash	Organic matter	Dry substance	Phosphorus		Potassium		Nitrogen		Weight of manure	Value per ton as determined by	
					Total	Soluble	Total	Soluble	Total	Soluble		Analysis	Crop production
Floats	Fresh manure	94 66	420 79	515.45	5.59	1.20	10.86	9 66	13.12	5.99	2,000	$ 3.11	$ 5.05
Floats	Weathered manure	77 00	308.37	385.37	5 34	1 07	7.28	6.69	8.71	1.97	1,915	2 20	3 96
Floats	Pounds lost	17 66	112.42	130.08	0 25	0 13	3.58	2.97	4.41	4.02	.....	.91	1.09
Floats	Percent lost	18.66	26.71	25 23	4 47	10.83	32.96	30.74	33.61	67.11	.....	29.26	21.58
Acid phosphate	Fresh manure	94.10	438.75	532.85	4 00	1 60	10.60	9.90	13.18	5.79	2,000	2.97	5.43
Acid phosphate	Weathered manure	78.92	271.45	350 37	3 32	0.98	6 57	6.05	9 02	1.84	1,892	2.04	4.62
Acid phosphate	Pounds lost	15.18	167.30	182.48	0 68	0.62	4 03	3.85	4.16	3.95	.....	.93	.81
Acid phosphate	Percent lost	16.13	38.13	34.25	17 00	38 75	38.02	38.89	31.56	68.22	.....	31.31	14.91
Kainit	Fresh manure	85.86	458 35	544.21	2.34	1.19	14.05	13.19	13 01	5 72	2,000	2.99	4.29
Kainit	Weathered manure	62 59	291.19	353.78	1.95	0.91	7.89	7.67	9.04	2.12	1,933	2.01	3 38
Kainit	Pounds lost	23.27	167 16	190.43	0 39	0 28	6.16	5.52	3.97	3.60	.....	.98	.91
Kainit	Percent loss	27.10	36.47	34.99	16 67	23 53	43 85	41.85	30 51	62.94	.....	32.77	21.21
Gypsum	Fresh manure	82.98	444.14	527.12	2 26	0 79	10.63	9.83	13 56	5.63	2,000	2.90	4.02
Gypsum	Weathered manure	59 19	297 05	356.24	2.04	0.62	4.85	4.75	9 54	2.55	1,936	1 94	3.45
Gypsum	Pounds lost	23.79	147 09	170.88	0.22	0 17	5.78	5.08	4.02	3.08	.....	.96	.57
Gypsum	Percent loss	28.67	33 11	32.41	9.73	21.52	54.37	51.67	29.65	54.71	.....	33.10	14.17
Untreated	Fresh manure	67.92	445 40	513 31	2.36	1.20	11.19	10.51	13.53	6 17	2,000	2.92	3.73
Untreated	Weathered manure	52 87	287.41	340.27	1.83	0.93	5 48	5.05	8 71	2.53	1,884	1.80	2.93
Untreated	Pounds lost	15.05	157 99	173.04	0.53	0.27	5.71	5.46	4 82	3.64	.....	1.12	.80
Untreated	Percent loss	22.15	35.47	33 71	22.46	22.50	51.02	51.95	35.63	59.00	.....	38.35	21.45
Average percent loss		22.54	33.98	32.12	14.07	23.43	44.05	43 02	32.19	62.39	.....	32.96	18.66

TABLE VIII—Average annual yields per acre of crops grown in manure tests for entire period ending with the year 1910.[1]

Experiment	Plot No.	Tons of manure applied per acre	Manure treatment	Corn bus.	Stover lbs.	Oats bus.	Straw lbs.	Wheat bus.	Straw lbs.	Clover lbs.	Timothy lbs.
[2]Continuous culture				a							
Yard manure on each crop every year											
Corn	5	2½		27.97	1,748						
Corn	6	5		37.66	2,112						
Corn average unfertilized		0		16.87	1,237						
Oats	5	2½				31.13	1,245				
Oats	6	5				38 67	1,757				
Oats average unfertilized		0				23.45	921				
Wheat	5	2½						14.17	1,773		
Wheat	6	5						18 36	2,302		
Wheat average unfertilized		0						8.21	1 007		
[2]Five-year rotation				a							
Corn, oats, wheat, clover and timothy	18	16		47.21	2,423	42.61	2,022	21 92	2,399	3,644	4,043
Yard manure on corn and wheat	20	8		42.64	2,163	37.98	1,693	18.22	1,958	3,019	3,501
Average unfertilized		0		29.09	1 646	31.78	1 334	10 98	1,122	1,967	2,494
[2]"Potato rotation," Potatoes, wheat and clover				b			Potatoes, bus.				
Yard manure on wheat	17	4					150.89	32 02	3,180	4,208	
Yard manure on wheat	18	8					157.14	33 29	3,301	4,614	
Yard manure on potatoes	30	8					182.96	32 63	3,229	4,361	
Yard manure on wheat	32	16					188.61	38.74	4,036	5,043	
Average unfertilized		0					143 22	27.29	2,660	3,664	
[3]"Barnyard manure test"				c							
Corn, wheat and clover rotation	2	8	Floats	58.56	3,290			25.40	2,765	4,202	
Yard manure on corn only	5	8	Acid phosphate	59.67	3,250			26.07	2,819	4,052	
	8	8	Kainit	53.84	3,169			21.84	2,482	3,405	
	12	8	Gypsum	57.78	3,368			25.19	2,759	3,691	
	15	8	None	50 63	2,873			20.09	2,260	3,060	
Average unfertilized		0		33 04	2,107			11.53	1 373	2 435	
[3]"Barnyard manure test"				c							
Corn, wheat and clover rotation	3	8	Floats	62.16	3,557			26.86	2,967	4,784	
Stall manure on corn only	6	8	Acid phosphate	63.71	3,474			26.76	2,981	4,764	
	9	8	Kainit	58.97	3,491			23 54	2,783	4,215	
	13	8	Gypsum	59.65	3,530			24 09	2,714	3,737	
	16	8	None	57 69	3,321			21.63	2,445	3,769	
Average unfertilized		0		33.04	2,107			11 53	1,373	2,435	

[1]For complete data concerning these experiments see Bulletins 182, 183 and 184, and Circulars 83, 92, 104, 114 and 120.
[2]Duration of test 17 years.
[3]Duration of test 14 years.
a 5-year period. b 6-year period. c 3-year period.

TABLE IX—Value of increase production of crops grown in continuous culture and rotation, with manure in various amounts and with reinforcing materials, given by periods.

Experiment	Plot No.	Tons of manure applied per acre	Manure treatment	Value of increase: First period		Second period		Third period		Average value of three periods	
				Per acre	Per ton of manure	Per acre	Per ton of manure	Per acre	Per ton of manure	Per acre	Per ton of manure
[1]Continuous culture				[a]							
Yard manure on each crop every year											
Corn	5	2½		$ 4.75	$1 90	$7.13	$2.85	$ 8.53	$3.41	$ 6.67	$2.67
Corn	6	5		9 13	1.83	13.29	2.66	14.62	2.82	12.29	2.46
Oats	5	2½		0 91	0.36	3.25	1.30	5 86	2.34	3.46	1.38
Oats	6	5		2.82	0.56	6.99	1.40	10.02	2.00	6.88	1.37
Wheat	5	2½		3 25	1.30	5 30	2.12	6.46	1 29	5.82	2.33
Wheat	6	5		5.85	1.17	9 40	1.98	11.72	2 34	10.12	2.02
[1]Five-year rotation				[a]							
Corn, oats, wheat, clover and timothy	18	16		22.35	1.40	39.66	2.48	59.31	3 71	8.52	2.66
Yard manure on corn and wheat	20	8		13.36	1.67	24.85	3.11	37.53	4.69	5.31	3.32
[1]"Potato rotation", Potatoes, wheat and clover				[b]							
Yard manure on wheat	17	4		5.64	1.41	14.66	3 64	.....	....	4.84	3 63
Yard manure on wheat	18	8		8.86	1.11	22.97	2 87	.....	....	7.07	2.65
Yard manure on potatoes	30	8		18.64	2.33	29.03	3.63	.....	....	8.92	3.35
Yard manure on wheat	32	16		16.81	1.05	33.16	2.07	. ..	....	11.97	2 24
[2]"Barnyard manure test"				[c]							
Corn, wheat and clover rotation	2	8	Floats	19.09	3.58	34.30	4.27	34.15	4 26	11.04	3.96
Yard manure on corn only	5	8	Acid phosphate	20.59	3.86	38.14	4.76	41.80	5.23	13.16	4.62
	8	8	Kainit	16.64	3.12	31.42	3.93	29.27	3.66	9.91	3.38
	12	8	Gypsum	17.61	3.31	33.25	4.16	25.66	3.21	9.53	3.45
	15	8	None	13.78	2.58	21.20	2.59	20.71	2.59	7.82	2.93
[2]"Barnyard manure test"				[c]							
Corn, wheat and clover rotation	3	8	Floats	25.10	4.70	41.29	5.16	44 92	5.62	13.93	5.05
Stall manure on corn only	6	8	Acid phosphate	23 13	4 34	45 62	5.70	47.81	5.98	15.28	5.43
	9	8	Kainit	19 92	3.73	37.24	4 66	39 52	4.94	12.34	4.29
	13	8	Gypsum	21 67	4.06	36.91	4.61	28.82	3.60	11.04	4.02
	16	8	None	15.64	2.93	28.96	3.61	28.31	3.54	9.94	3 73

[1] Duration of test 17 years. [2] Duration of test 14 years. a 5-year period. b 6-year period. c 3-year period.

RETURN FROM MANURE

The net return realized from a ton of yard manure under general farming conditions depends upon the soil, method of cultivation and crops grown. The Station has obtained an increase amounting to $4.69 per ton from yard manure used at the rate of 8 tons per acre in a 5-year rotation of corn, oats, wheat, clover and timothy; four tons being applied to corn and four tons to wheat, this return being the average for the third 5-year period, as shown in Table IX. The average return from yard manure used in all tests in which rotation is practiced has been $2.97 per ton for the whole time. If the return is computed for the last 5-year period it will be much greater than this figure.

In Tables VIII and IX is shown a comparison of the yields and value of increase per ton of manure under different methods of crop rotation and continuous cropping, also a comparison of the yields and return from yard and stall manure under the same system of cropping and treatment. These tables also furnish a basis for calculating the relative values of the yard manure used in all tests and that which was sampled and used on plot 15 of the manure test. Taking the average return per ton from the rotation tests it is found to be $2.97 for untreated manure while that used upon plot 15, also untreated (Table IX), has given a return of $2.93 per ton, showing the close agreement between the manure termed "yard manure" and applied to all plots except those in the manure test and that weathered for three months and used as "yard manure" in these manure tests.

RATE OF APPLICATION OF MANURE

Assigning yard manure the value obtained by chemical analysis of $1.80 per ton (Table VII) it will be observed from data in Table IX that oats grown continuously upon the same soil is the only crop that fails to give a return sufficient to pay for the manure used.

This table also shows that the return per ton of manure has in every case been greater from the smaller applications, where other conditions were alike, but the return per acre has been greater from the larger quantities. Hence when the supply of manure is limited it is better to cover all the land with it and supplement with fertilizers, also spread over all the land, rather than to use the manure and fertilizers more heavily, each on only part of the land.

TABLE X—Average annual increase from manures differently treated, cost of treatment and net gain per ton of manure.

Plot No.	Manure and treatment	Average annual increase per acre					Cost of treatment per acre for one rotation	Value of increase per acre	
		Corn 13 crops		Wheat 13 crops		Hay 10 crops lbs.		Total per acre for one rotation	Net per ton of manure 13 yr. av.
		Grain bus.	Stover lbs.	Grain bus.	Straw lbs				
2	Yard manure and floats	24.08	1,136	12.98	1 266	1,605	$1.40	$ 33.12	3.96
3	Stall manure and floats	29.78	1,481	14.97	1,541	2,418	1.40	41.79	5.05
5	Yard manure and acid phosphate	29.46	1,262	15 08	1,499	1,925	2 40	39.39	4 62
6	Stall manure and acid phosphate	33.57	1,495	16.17	1,694	2,644	2.40	45.85	5 43
8	Yard manure and kainit	23 26	1 198	11.42	1,206	1,203	2.70	29.73	3 38
9	Stall manure and kainit	27.88	1,517	12 91	1,486	1,924	2.70	37.02	4.29
12	Yard manure and gypsum	23.18	1,134	11.55	1,195	928	1.00	28.59	3.45
13	Stall manure and gypsum	27.08	1,412	12.31	1,306	1,273	1.00	33.12	4.02
15	Yard manure untreated	18.30	762	9 99	965	804	....	23.46	2.93
16	Stall manure untreated	23.59	1,102	10.62	1,107	1,427	...	29.82	3.73

THE REINFORCEMENT OF MANURE

The object of treating manure with preservatives or reinforcing materials is either to prevent the loss of nitrogen or to add directly to its fertilizing value. Gypsum and kainit have been used for prevention of escape of ammonia from manure for many years, but the experiments which have been conducted at this Station for 15 years show that, while these materials add materially to the value of the manure, the addition of phosphorus-carrying materials produces so much larger increase of crop as to render the use of gypsum or kainit unprofitable, even though they were to cost nothing, as shown by Table XI, which gives the increase obtained by the addition of floats, acid phosphate, kainit and gypsum.

Table XI shows that the yields from plots receiving manure reinforced with gypsum and kainit have returned a profit of 29 to 56 cents per 40 pounds above the cost of treatment, while floats and acid phosphate have increased the average net profit to 89 cents and $1.39 respectively per 40 pounds when used with yard manure, and to $1.18 and $1.40 per 40 pounds when used with fresh manure. The results of 13 years' experiments, Table IX, show that these materials are giving an increased return for every rotation. The return from acid phosphate and stall manure during the third rotation is $2.76 per ton net after allowing $2.92 for the manure and 30c for the acid phosphate, while the net return during the first rotation was only $1.12 per ton. That for the floats has been $2.55 and $1.63 per ton for the third and first periods respectively.

TABLE XI—Financial statement of returns from reinforced manure.

	Return for treatment with 40 lbs. of materials	Cost of treatment per ton of manure	Net profit for treatment	Interest on investment Percent
Value of increase due to floats used with stall manure....	$1.32	$ .145	$1.175	810
Value of increase due to floats used with yard manure....	1.03	0.145	0.885	610
Value of increase due to acid phos. used with stall manure	1.70	0 300	1.400	466
Value of increase due to acid phos. used with yard manure	1.69	0.300	1.390	463
Value of increase due to kainit used with stall manure...	.56	0.340	0.220	64
Value of increase due to kainit used with yard manure...	45	0.340	0.110	32
Value of increase due to gypsum used with stall manure.	.29	0.125	0.165	132
Value of increase due to gypsum used with yard manure.	.52	0.125	0 395	316

These experiments also serve to contrast the relative values of open yard manure and phosphated stable manure applied directly to the field from the stable, (Table X). The average return from a ton of open yard manure being $2.93 for the 13 years, while that from a ton of stall manure treated with 40 pounds of acid phosphate has been $5.43 for the same period, a difference of $2.50 in favor of

phosphated stall manure. 80c of this is due to better care of manure and $1.70 is due to the treatment with phosphate. The same comparison with the use of 40 pounds of floats shows a difference of $2.12 in favor of stall manure and floats, 80c of which is due to better care of the manure and $1.32 is due to the addition of floats.

The most economical and convenient method of treating manure with phosphatic materials is to keep a sack or bin of either floats or acid phosphate convenient to the stall and to scatter a pound per day of the material over the manure in the stall for each horse or cow and one pound per day for every six sheep or hogs. If large quantities of manure are to be treated at one time it is best to treat it with 40 pounds per ton of manure as it is put into the spreader. The first method is preferable because the phosphate will be in contact with the manure longer and be more thoroughly mixed with it.*

SUMMARY

The liquid excrement from farm animals contains nearly half the nitrogen and potassium voided by them and should be carefully preserved.

When steers are fed on cement floors the value of the manure produced is more than $4.00 per year greater for each animal than when fed on earth floors.

"Fire fanging" of manure may be prevented by excluding air from the interior of the pile.

The least amount of nitrogen will be lost from stored manure if animals are kept on it or it is kept in a moist, well packed condition.

If the animals are removed from box stalls for a considerable time the loss of nitrogen from the manure will be much greater than it will be if the animals are kept in the stall.

Open barnyard manure is about one-half as valuable as stall manure.

Stall manure appears to be more effective in rendering phosphorus available from floats and other materials carrying phosphorus in slightly available form, than yard manure.

The addition of phosphatic materials to manure greatly increases its fertilizing value and pays a handsome return for the trouble. For this purpose phosphatic materials will prove more valuable on most Ohio soils than gypsum or kainit.

Manure used in connection with continuous cropping will not maintain the maximum yield but when used in connection with crop rotation it increases the yield of all crops grown in that rotation.

Manure used in conjunction with a complete fertilizer high in phosphorus will give better returns than when either is used alone.

*Other experiments in progress at this station indicate that this point is important, in the use of floats, at least.

ADDENDA

Table XII—Weight and value of solid and liquid excrement, and of nitrogen, phosphorus and potassium contained per animal per year.

TABLE XIII—Production and value of manure, including bedding, produced at the Ohio Experiment Station under practical feeding conditions on cement and earth floors.

TABLE XIV—Water holding capacity of and percent of fertilizing elements contained in bedding materials.

TABLE XV—Percent of fertilizer constituents in feeds.

TABLE XVI—Percentage composition of fresh manure, including bedding as taken from stalls.

TABLE XVII—Composition of fresh and leached steer manure untreated, expressed as pounds per ton of fresh manure.

TABLE XVIII—Composition of fresh and leached steer manure treated with 40 pounds of Floats per ton, expressed as pounds per ton of fresh manure.

TABLE XIX—Cemposition of fresh and leached steer manure treated with 40 pounds of Acid Phosphate per ton, expressed as pounds per ton of fresh manure.

TABLE XX—Composition of fresh and leached manure treated with 40 pounds of Kainit per ton, expressed as pounds per ton of fresh manure.

TABLE XXI—Composition of fresh and leached steer manure treated with 40 pounds of Gypsum per ton, expressed as pounds per ton of fresh manure.

TABLE XXII—Nitrogen lost by fresh stall manure due to complete air drying.

TABLE XII—Weight and value of solid and liquid excrement, and of nitrogen, phosphorus and potassium contained, per animal per year.

Animal		Total excrement	Elements contained						Total value
			Nitrogen		Phosphorus		Potassium		
		Lbs.	Lbs.	Value	Lbs.	Value	Lbs.	Value	
Horses:	Solid	12,957	64.14	$10.16	16.84	$1.39	25.92	$1.37	$12.92
	Liquid	2,920	35.04	5.55	.....	....	36.21	1.92	7.47
	Total	15,877	99.18	15.71	16.84	1.39	62 13	3.29	20.39
Cattle:	Solid	18,980	61.50	9.74	17.08	1.41	23 54	1.25	12.40
	Liquid	7,081	67.27	10.66	.85	.07	55.94	2.97	13.70
	Total	26,061	128.77	20.40	17.93	1.48	79.48	4.22	26.10
Sheep:	Solid	821	5.34	.84	1 64	.135	1.56	08	1.06
	Liquid	546	9.20	1.46	.07	.005	9.64	.51	1.97
	Total	1,367	14.54	2.30	1.71	.14	11.20	.59	3.03
Hogs:	Solid	2,190	13.14	2.08	4.38	.36	8.10	.43	2.87
	Liquid	1,205	3 62	.57	.66	.05	10.00	.53	1.15
	Total	2,375	16 76	2.65	5 04	.41	18.10	.96	4.02

Values assigned the fertilizer constituents of manure in this bulletin are nitrogen 15.84 cents phosphorus 8.25 cents, potassium 5.3 cents per pound.

TABLE XIII—Production and value of manure, including bedding, produced at the Ohio Experiment Station under practical feeding conditions on cement and earth floors.

Per 1,000 pounds live weight	Number of animals	Pounds per day	Pounds per year	Value per year	Value per ton
Cattle (steers) cement floors	28	47 5	17,338	$25.66	$2.96
Cattle (steers) earth floors	30	41.3	15 075	21.18	2.81
Difference in favor of cement floors	..	6.2	2,263	4.48	0.15

TABLE XIV—Water holding capacity of, and fertilizing elements contained in bedding materials.*

	Material	Water retained by 100 pounds of material after 24 hours	Fertilizing elements in 100 pounds of material		
			Nitrogen	Phosphorus	Potasssium
		Lbs.	Lbs.	Lbs.	Lbs.
1	Wheat straw	220	0.53	0 092	0.830
2	Oats straw	220	0.58	0 087	1 096
3	Dead leaves	162	0 80	0.131	0.249
4	Peat moss	1,300	0.80	.....	.....
5	Sawdust	435	0.20-0.70	0.131	0.581
6	Spent tan	450	0.50-1 00	.....	.....
7	Peat	600	1 00-2 00	.....	.....

* 1-2—Analyses by Ohio Experiment Station. Other data from Farmers' Bulletin 192, United States Department of Agriculture.

TABLE XV—Fertilizing constituents in 100 pounds of feeds.*

	Material	Nitrogen	Phosphorus	Potassium
		Lbs.	Lbs.	Lbs.
1	Wheat	1.98	0 349	0.354
2	Oats	2.01	0.410	0.579
3	Corn	1.76	0.239	0.340
4	Corn stover	0.81	0.067	0 780
5	Corn cobs	0.50	0 026	0.639
6	Clover hay	2.17	0.183	1 121
7	Timothy hay	0.84	0 131	1 337
8	Alfalfa hay	2.51	0.290	1.661
9	Soybeans	5.43	0.625	1.868
10	Soybean straw	2.00	0.069	0.682
11	Potatoes	0 34	0.070	0.482
12	Meadow hay	1.02	0.179	1.096
13	Wheat bran	2.46	0.119	1.187
14	Linseed meal	5 26	0.070	1.030
15	Cotton seed meal	6.78	1.228	1.212
16	Barley	1 98	0.336	0 374
17	Milk	0.51	0 074	0.125
18	Blue grass	1.25	0.175	1.303
19	Millet	1 69	0 188	2.391
20	Cowpea hay	0.38	0.057	0.382
21	Corn silage	0.43	0.048	0.307
22	Brewers' grain	1.01	0.183	0.042

* 1-10 from Ohio Experiment Station, 11-22 from Henry's "Feeds and Feeding."

TABLE XVI. Percentage composition of fresh manure, including bedding, as taken from stalls.

Laboratory number	Moisture	Ash		Organic matter		Phosphorus		Potassium		Nitrogen	
		Total	Water soluble	Total	Water soluble	Total	Water soluble	Total	Water soluble	Total	Water soluble
Horse manure											
12,693	50.05	8.60	... .	31 35	....	.123	.008	.564	314	.633	256
12,696	62.72	4 51	.....	32.77	. ...	.116	.084	647	.308	.732	.413
3,552	61.92	3.86	2.138	34 20	1.512	.092	067	.635	.603	.705	.402
3,553	61.94	4.23	2.109	33.82	1.558	.101	.069	.696	695	.711	.389
Average...	59 16	5 30	2.123	33 04	1.540	.108	.057	.636	.480	695	.365
Cow manure											
3,550	79.13	2.37	1.57	18.50	1.32	.0996	.0472	.529	.505	.568	.284
3,551	78 96	2.52	1 63	18 50	1.33	.0935	0499	.511	.502	.575	.286
Average...	79.05	2.45	1.60	18 50	1.33	.0965	.0486	.520	.504	.572	285
Steer manure											
10,896	75.24	3.96	.....	20.80	.....	1615	.0829	.4068	.4068	.515	.168
2,225	76.54	2.08	1.199	21.38	1.231	.1221	.0695	.4238	.4128	.661	.283
3,556	72.93	3.63	.....	23 42	.....	.0792	.0424	.6518	.6518	.600	.281
5,322	72.59	3 75	.....	23 66	.....	.1336	.0703	.5804	.5347	.874	483
5,411-5	73.35	3.56	.....	23.09	.....	.0880	.0346	.6696	.6227	.728	.328
6,996	76 56	2 93	.....	20.50	.....	.1110	.0581	.4557	.4266	.424	.189
6,270	80.96	2 40	.....	16 64	.....	.1027	.0590	.5046	.4990	.441	.221
12,697	80.08	2.86	.....	17 05	.....	.1319	.0848	.3030	3030	.469	.217
5,078	81.08	3 05	.....	15.87	.....	.3155	.0865	.4225	.3768	.892	.613
5,077	79 11	3.13	.....	17 76	.....	.3164	.0979	.4050	.3793	.753	.443
5,079	81.26	3 01	.....	15.73	.....	.3291	.1066	.4374	.3602	.742	.486
5,076	80.66	2 84	.....	16.51	.....	.2815	.1118	.4009	.3353	.756	.452
5,082	78.99	3.92	.....	17.09	.....	.3557	.0882	.5760	.3404	.743	.431
5,083	80.59	2 93	.....	16.49	.....	.2910	.0966	.3478	.2988	.750	.478
5,075	77.39	3 67	.....	18 94	.....	.3496	.0546	.3693	.3527	.570	272
5,074	79.99	3.56	.....	16 45	.....	.3288	.0765	.4292	.3511	.825	.534
5,080	76.97	3.91	.....	19.13	.....	.3006	.0533	.3718	.3395	.749	.419
2,676	79.17	2 60	1.399	18 22	1.184	1288	.....	.4494	.4277	.899	.487
2,677	75.98	2.94	1.590	21 08	1 393	.1425	....	.5408	.4962	.915	.484
2,678	79.16	2.64	1.447	18.21	1.422	.1313	.....	.4999	.4411	.814	.436
2,679	76 18	2.78	1.487	21 04	1.443	.1305	.....	.5466	.5425	.917	.543
Average...	77.85	3.15	1.430	19.00	1.330	.2062	.0749	.4568	.4231	.716	.393
Sheep manure											
2,221	63.85	3.94	2 206	32 21	1.884	.1767	.0952	.789	.....	.902	.307
2,222	67.04	3 68	2.341	29.28	1.650	.1935	.1141	.806	.....	1.065	.490
2,223	69.44	3.69	2.194	26.86	1.848	.1600	.0875	.818	.....	.961	.438
2,224	66.29	4.88	2.924	28.84	1.971	.1700	.0969	.942	.....	1.022	.451
11,398	64.00	5.24	2.770	30.76	2.270	.2255	.0983	.915	.854	1.513	.697
11,399	66.25	4.48	2.204	29.27	2.177	.2006	.0975	.857	.738	1.297	.530
11,400	64.88	5.29	2.687	29.83	1.820	.2312	.1140	.871	.702	1 425	.615
11,401	63.58	5.49	2.459	30.93	2.286	2189	.1053	1.041	1.011	1 512	.650
13,399	60.08	5.33	.....	34.60	.....	.2932	.2001	1.158	1.103	1.855	.928
13,400	57.36	5 55	.....	36.06	.....	.2906	.1720	1.172	1.095	1.666	.620
13,401	58.20	5.73	.....	36.07	.....	.2770	.1783	1.134	1.134	1.769	.730
13,402	54.55	6.13	. ...	39.32	.....	.2984	.2014	1.301	1.169	1.896	.806
6,261	52.94	8.25	.....	25.81	.....	.2465	.....	1.059	.....	1.502	....
6,262	63.31	4.72	.....	31.96	.....	.2421	.....	.975	.....	1 507	....
6,263	65.23	4.68	.....	30.09	.....	.2203	.....	1.118	.....	1.458	....
6,264	67.18	4.37	.....	28.45	.....	.1901	.....	.962	.....	1.297	....
6,294	63.90	5.09	.....	31.01	.....	.2083	.....	1.168	.....	1.480	....
6,295	68.17	4.51	.....	27 32	.....	.2272	.....	1.069	.....	1.600	....
6,296	67.17	4.27	.....	28.56	.....	.2159	.....	1.0o8	.....	1.670	....
6,297	68 65	4.02	.....	27.32	.....	.1726	.....	.987	... .	1.400	....
Average...	63.61	4 97	2.473	30.73	1.988	.2229	.1300	1.010	.976	1.439	.605

TABLE XVII—Composition of fresh and leached steer manure UNTREATED, expressed in pounds per ton of fresh manure.

	Laboratory number	Moisture	Ash	Organic matter	Dry matter	Phosphorus		Potassium		Nitrogen		Weight of manure	Year
						Total	Water soluble	Total	Water soluble	Total	Water soluble		
Fresh.....	10,896	1504.80	79 20	416.00	495.20	3.23	1.66	8.14	8.14	10.30	3.36	2,000	1907
Leached.....	13,756	1719.50	65.68	254.79	320.47	2.46	1.27	3.34	2.82	7 18	1.14	2,040	1907
Lbs. lost.....	.....	.....	13.52	161.21	174.73	0.77	0.39	4.80	5.32	3.12	2.22	.....	1907
Fresh.....	2,225	1530.78	41.60	407 58	449.18	2.44	1.39	8.48	8 26	13 23	5.65	2,000	1908
Leached	2,484	1594.30	31.38	374.30	405.68	1.86	1.01	4.07	3.76	9 03	3.36	1,900	1908
Lbs. lost.....	... .	.....	10.22	33.28	43.50	0.58	0.38	4.41	4.50	4 20	2.29	.....	1908
Fresh.....	3,556	1458.60	72.60	468.40	541.00	1.68	0.84	14.36	13.03	12.08	5.62	2,000	1909
Leached.....	4,222	1758.90	48.65	287.15	335.80	0 78	0.82	5.19	5.12	8.52	3.97	2,070	1909
Lbs. lost.....	.....	.....	23.95	181.25	205.20	0.90	0.02	9.17	7.91	3 56	1.65	.....	1909
Fresh..... ..	5,322	1451.80	75.00	473.20	548.20	2.67	1.40	11 60	10.69	17.48	9.66	2,000	1910
Leached.....	5,327	1340.00	58.77	261 28	320.05	2.56	0.94	6.53	6 27	9.48	1.93	1,660	1910
Lbs. lost.....	.....	.....	16.30	211 92	228.15	0.11	0.46	5.07	4.42	8.01	7.73	....	1910
Fresh.....	5,411-5	1467 00	71.20	461.80	533 00	1.76	0.69	13.39	12.45	14.56	6 57	2,000	1911
Leached.....	5,459-5	1430.63	59.85	259.52	319 37	1.47	0.63	8.26	7.24	9.35	2.27	1,750	1911
Lbs. lost.....	.....	.....	11.35	202.28	213.63	0.29	0.06	5.13	5.21	5.21	4.30	.....	1911
Average													
Lbs. fresh ...	.....	.....	67.92	445.40	513.31	2.36	1.20	11.19	10.51	13.53	6.17	2,000	....
Lbs. leached.	.....	..... .	52.87	287 41	340.27	1.83	0.93	5.48	5.05	8 71	2.53	1,884	....
Lbs. lost	.....	.....	15.05	157.99	173.04	0 53	0 27	5.71	5.46	4.82	3.64	.....	....
Percent lost ...	.....	.....	22.15	35.47	33.71	22.46	22.50	51.02	51.95	35.63	59.00	... .	....

TABLE XVIII—Composition of fresh and leached steer manure treated with 40 lbs. of FLOATS per ton, expressed as pounds per ton of fresh manure.

	Laboratory number	Moisture	Ash	Organic matter	Dry matter	Phosphorus		Potassium		Nitrogen		Weight of manure	Year
						Total	Water soluble	Total	Water soluble	Total	Water soluble		
Fresh	10,900	1530.80	120.20	349.00	469 20	9.20	1.520	7.38	6 58	10.70	4.28	2,000	1907
Leached	13,760	1590.31	98.95	310.74	409 69	9.05	1 320	3.52	3.47	7.46	1.06	2,170	1907
Lbs. lost	.....	.....	21.25	38.26	59.51	0.15	0.200	3.86	3.11	3.24	3 22	.....	1907
Fresh	2,229	1513.80	69.64	416.56	486.20	5.31	1.190	8.87	7.74	11.94	5.03	2,000	1908
Leached	2,480	1566.16	67.90	303.20	371.10	4.83	1 030	6.39	5.66	9.32	2.92	1,940	1908
Lbs. lost	.....	.....	1.74	113.36	115.10	0.48	0.160	2.48	2.08	2.62	2.11	.....	1908
Fresh	3,554	1474.00	81.80	444.00	525.80	2 25	0.890	13.03	12.70	11.91	6.26	2,000	1909
Leached	4,218	1733.10	52.71	313.29	366.00	2 15	0.850	7 03	6.52	7.92	2.25	2,100	1909
Lbs. lost	.....	.....	29.09	130.71	159.80	0.10	0.040	6.00	6.18	3.99	4.01	.....	1909
Fresh	5,323	1436.60	107.00	473.60	580.60	5.98	1.480	12.26	10.11	16.08	8.88	2,000	1910
Leached	5,328	1326.90	88.44	306.26	394 70	7.16	0.880	8.53	8.13	8.86	1.34	1,704	1910
Lbs. lost	.....	.....	18 56	167.34	185.90	*	*	3.73	1.98	7.22	7.54	.....	1910
Fresh	5,411-1	1449.80	79.40	470.80	550.20	2.78	0 724	12.77	11.17	14.97	5.53	2,000	1911
Leached	5,459-1	1312.06	87.31	260.62	347.93	4.97	0 729	10 93	9.67	9.98	2.29	1,660	1911
Lbs. lost	.....	.....	*	*	*	*	*	1.84	1.50	4 99	3.24	.....	1911
Average													
Lbs. fresh	.....	1481.00	94 66	420.79	515.45	5.59	1.200	10.86	9 66	13.12	5 99	2,000	....
Lbs. leached	.....	1505.70	77.00	308.37	385.37	5.34	1 070	7.28	6.69	8.71	1.97	1,915	....
Lbs. lost	.....	.....	17.66	112.42	130.08	0.25	0.130	3 58	2.97	4.41	4.02	.....	....
Percent lost	.....	.....	18.66	26.71	25.23	4.47	10.830	32.96	30.74	33 61	67.11	.....	....

* Omitted from average.

TABLE XIX—Composition of fresh and leached steer manure treated with 40 lbs of ACID PHOSPHATE per ton, expressed as pounds per ton of fresh manure.

	Laboratory number	Moisture	Ash	Organic matter	Dry matter	Phosphorus		Potassium		Nitrogen		Weight of manure	Year
						Total	Water soluble	Total	Water soluble	Total	Water soluble		
Fresh.....	10899	1540.80	101.40	357 80	459.20	5.70	2.28	6.880	6 88	9.86	3.04	2,000	1907
Leached.....	13759	1684.20	85.89	269.91	355.80	4 79	1 51	2.990	2 51	7.18	0.84	2,040	1907
Lbs. lost.....	....	.....	15.51	87.89	103.40	0.91	0.77	3.890	4.37	2.68	2.20	.....	1907
Fresh.....	2228	1559.70	62.40	377.90	440.30	4 01	1.66	8 206	8 13	13 08	6.25	2,000	1908
Leached.....	2481	1535.30	62.70	322 00	384 70	4.17	1.16	6.284	5.94	10.90	2.69	1,920	1908
Lbs. lost.....	....	....	*	*	*	*	*	1 922	2 19	2.18	3.56	.....	1908
Fresh.....	3555	1442.60	75 00	482.00	557.00	2,13	1.11	14 310	12.33	12.50	5.92	2,000	1909
Leached.....	5219	1751.40	50.13	281.87	332.00	1.91	0.88	7.670	6.86	8.80	2.81	2,080	1909
Lbs. lost.....	....	.....	24.87	200.13	225.00	0.22	0.23	6.640	5.47	3 70	3.11	.....	1909
Fresh	5324	1434.60	103.40	461 60	565 00	5.38	2.59	11 040	10 44	16.46	8.16	2,000	1910
Leached.....	5329	1351.06	98.38	270 52	368 90	5.09	1.29	7 450	7.10	8.86	1.12	1,720	1910
Lbs. lost.....	...	.....	5.02	191.08	196.10	*	*	3.590	3.34	7.60	7.04	.....	1910
Fresh.....	5411-2	1449 80	96.60	453.60	550 20	4.17	1.42	12.572	11.72	14.01	5.59	2,000	1911
Leached.....	5459-2	1355.24	81 26	263 50	344.76	3.27	0 56	8.452	7.84	9 36	1 74	1,700	1911
Lbs. lost.....	....	.....	15.34	190.10	205.44	0.90	0.86	4.120	3 88	4.65	3.85	.....	1911
Average													
Lbs. fresh....	....	.....	94 10	438.75	532.85	4 00	1.60	10 600	9.90	13.18	5 79	2,000	....
Lbs. leached.	...	.....	78 92	271.45	350 37	3.32	0.98	6.570	6.05	9 02	1 84	1,892	....
Lbs. lost.....	....	.....	15.18	167.30	182 48	0 68	0.62	4.030	3 85	4.16	3.95	.....	....
Percent lost....	...	.....	16.13	38.13	34.25	17.00	38.75	38 020	38.89	31.56	68.22	.....	....

*Omitted from average.

TABLE XX—Composition of fresh and leached manure treated with 40 pounds of KAINIT per ton, expressed as pounds per ton of fresh manure.

	Laboratory number	Moisture	Ash	Organic matter	Dry matter	Phosphorus		Potassium		Nitrogen		Weight of manure	Year
						Total	Water soluble	Total	Water soluble	Total	Water soluble		
Fresh.....	10898	1523 60	107.40	429.00	536.40	2.89	1.35	10.70	10.66	9.76	3.04	2,000	1907
Leached.....	13758	1675.10	83.64	291.51	375 15	2.47	1.31	4.94	4 96	6.68	0.31	2,050	1907
Lbs. lost.....	.....	.....	23.76	137.49	161.25	0 42	0.04	5.76	5.70	3.08	2.73	.....	1907
Fresh	2227	1485.90	72.30	441.76	514 06	2.25	1.19	13.52	13 22	12.61	5.94	2,000	1908
Leached.....	2482	1661.34	57 26	241.26	298 52	2.04	1.01	8.05	8.04	9.77	2.60	1,960	1908
Lbs. lost.....	....	.....	15.04	200.50	215 54	0.21	0.18	5.47	5.18	2.84	3 34	.....	1908
Fresh	3557	1478.60	64.00	458.00	521.00	1.80	1.01	14.46	12.17	11.97	6 20	2,000	1909
Leached.....	4220	1686.20	42.40	342.00	384.40	1.75	1.05	7.61	6.73	8.14	2.60	2,120	1909
Lbs. lost.....	....	.....	20.60	116.00	136.60	0.05	*	6.85	5.44	3.83	3.60	.....	1909
Fresh.....	5325	1432.00	93 80	492.80	586 60	2.85	1 59	14.61	13.37	16.56	8.14	2,000	1910
Leached.....	5330	1336.50	67.04	302 46	369.50	2.38	0.85	10.04	10.00	10.64	2.76	1,706	1910
Lbs. lost.	....	.....	26.76	190.34	217.10	0.47	0.74	4.57	3.37	5.92	5 38	.. .	1910
Fresh...	5411-3	1437.00	92 80	470.20	563.00	1.89	0.65	16.94	16.52	14.16	5.30	2,000	1911
Leached.....	5459-3	1488.71	62.59	278.70	341.29	1.13	0.46	8.84	8.63	9.95	2.37	1,830	1911
Lbs. lost.....	....	.....	30.21	191.50	221.71	0.76	0.19	8.10	7.89	4.21	2.93	.....	1911
Average													
Lbs. fresh....	....	.....	85.86	458.35	544.21	2.34	1.19	14.05	13.19	13.01	5.72	2,000	....
Lbs. leached.	....	.....	62.59	291.19	353.78	1.95	0.91	7.89	7.67	9.04	2.12	1,933	...
Lbs. lost.....	....	.....	23.27	167.16	190.43	0.39	0.28	6.16	5 52	3.97	3.60	.....	..
Percent lost....	....	.....	27.10	36.47	34.99	16.67	23.53	43.85	41.85	30.51	62.94	.....	....

* Omitted from average.

TABLE XXI—Composition of fresh and leached steer manure treated with 40 lbs. of GYPSUM per ton, expressed as pounds per ton of fresh manure.

	Laboratory number	Moisture	Ash	Organic matter	Dry matter	Phosphorus		Potassium		Nitrogen		Weight of manure	Year
						Total	Water soluble	Total	Water soluble	Total	Water soluble		
Fresh	10897	1520.00	104.60	375 40	480.00	2.76	0.79	7.87	7.87	9.68	2.12	2,000	1907
Leached	13757	1686.90	74.71	267 19	341.90	2.66	0 76	2.56	2.49	7 93	1 46	2,030	1907
Lbs. lost	.....	.....	29.89	108 21	138 10	0.10	0 03	5.31	5 38	1.75	0.66	.....	1907
Fresh	2226	1468.70	74.32	456.94	531.26	2 32	0.98	9.33	9.18	14.74	6 93	2,000	1908
Leached	2483	1530.56	50 06	279 36	329.42	1.94	0.60	3.85	3.63	9.83	3.31	1,860	1908
Lbs. lost	....	.....	24.26	177 58	201.84	0.38	0.38	5.48	5.55	4.91	3 62	.....	1908
Fresh	3558	1474.00	65.60	460.20	525.80	1.69	0 95	12.88	11.11	11.92	5 94	2,000	1909
Leached	4221	1733.30	38 22	328.23	366.45	1.45	0.73	4.05	3.93	7.13	2 04	2,100	1909
Lbs. lost	....	.....	27.38	131.97	159.35	0.24	0.22	8.83	7 18	4.79	3 90	.....	1909
Fresh	5326	1440 20	92.60	486.20	578 80	2.55	1.32	11 01	9 98	16.40	8.24	2,000	1910
Leached	5331	1533 68	98 60	267.70	366.30	2.39	0.77	7.15	7 07	11.60	3.83	1,900	1910
Lbs. lost	....	. ..	*	*	*	0.16	*	3.86	2 91	4 80	4.41	.....	1910
Fresh	5411-4	1428 60	87.40	484.00	571 40	1.97	0.43	12.03	11.03	15.07	4.90	2,000	1911
Leached	5459 4	1403 00	73 75	313 43	387.18	1.77	0 37	6 63	6 61	11.20	2.11	1,790	1911
Lbs. lost	....	.....	13.65	170.57	184.22	0.20	0.06	5.40	4.42	3.87	2.79	.....	1911
Average													
Lbs. fresh	....	. .. .	82.98	444.14	527.12	2.26	0.79	10 63	9 83	13.56	5.63	2,000	....
Lbs. leached	....	... . .	59.19	297.05	356.24	2 04	0.62	4.85	4 75	9.54	2.55	1,936	....
Lbs. lost	....	.....	23.79	147.09	170.88	0 22	0.17	5.78	5.08	4.02	3.08	.....	....
Percent lost	....	.....	28.67	33.11	32.41	9 73	21.52	54.37	51.67	29 65	54.71	.....	....

* Omitted from average.

TABLE XXII—Nitrogen lost by fresh stall manure due to complete air drying.

Cattle manure				Horse manure			
Lbs. nitrogen per ton fresh	Lbs. nitrogen per ton air dry	Lbs. loss due to air drying	Percent loss	Lbs. nitrogen per ton fresh	Lbs. nitrogen per ton air dry	Lbs. loss due to air drying	Percent loss
11.42	7 925	3 495	30.60	14.162	9.578	4.884	34.48

The data in Table XXII shows the loss of nitrogen from a sample of fresh stall manure air dried at a temperature of 60° C. for a period of seven days without being subjected to leaching.

The data in Tables XII to XXII inclusive relative to the leaching of manure are compiled from analyses made before and after three months exposure in an open barnyard.